



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

June 30, 1971

MEMORANDUM

TO: KSI/Scientific & Technical Information Division
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned
U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,417,400

Corporate Source : Hughes Aircraft Company

Supplementary
Corporate Source : _____

NASA Patent Case No.: XGS-02290


Gayle Parker

Enclosure:
Copy of Patent

FACILITY FORM 602	(ACCESSION NUMBER)	<u>N71-28809</u>	(THRU)
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Dec. 17, 1968

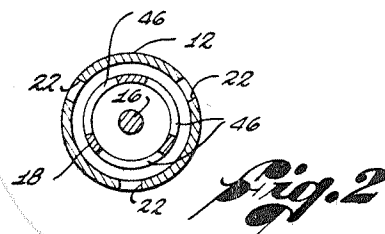
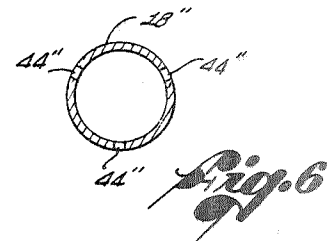
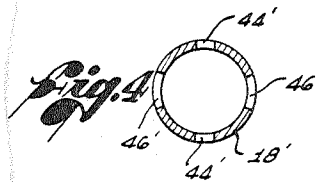
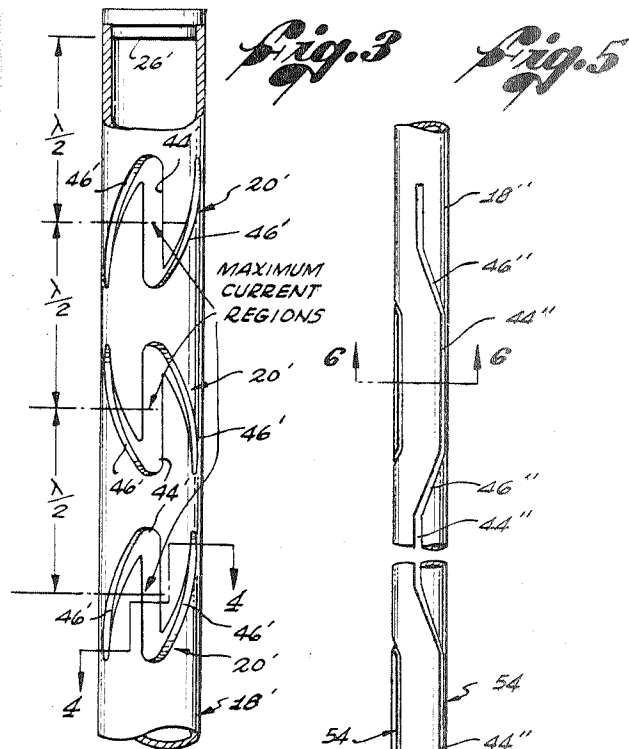
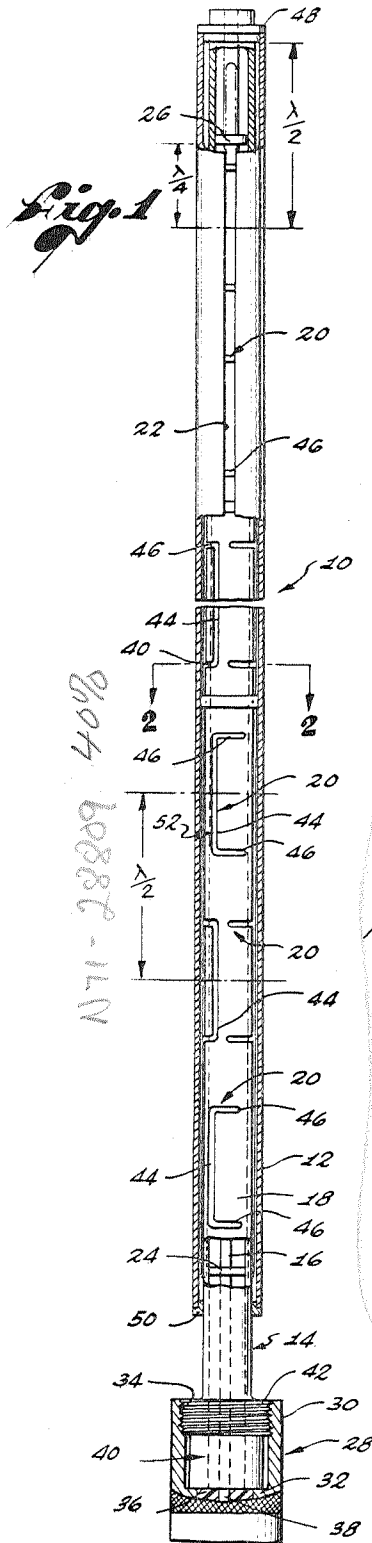
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3,417,400

TRIAxIAL ANTENNA

Filed April 25, 1966

3 Sheets-Sheet 1



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TRIAXIAL ANTENNA

Filed April 25, 1966

3 Sheets-Sheet 2

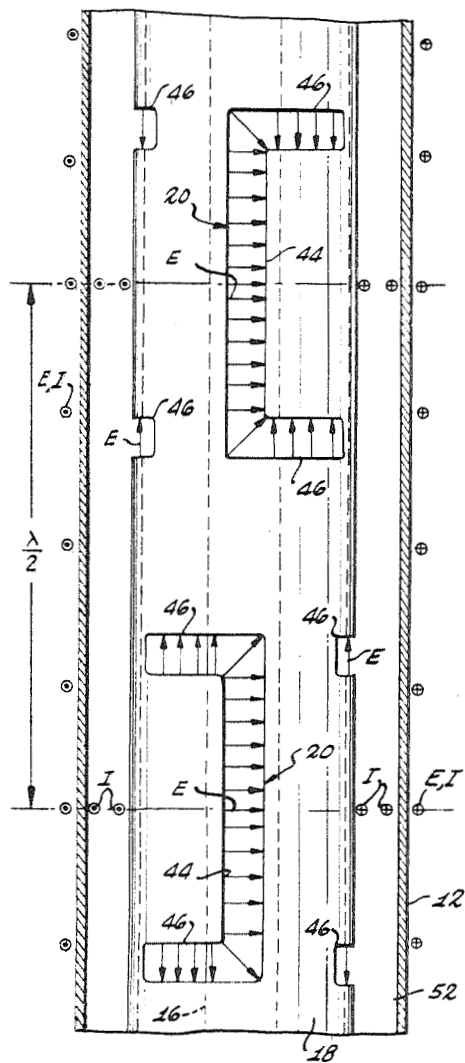


Fig. 7

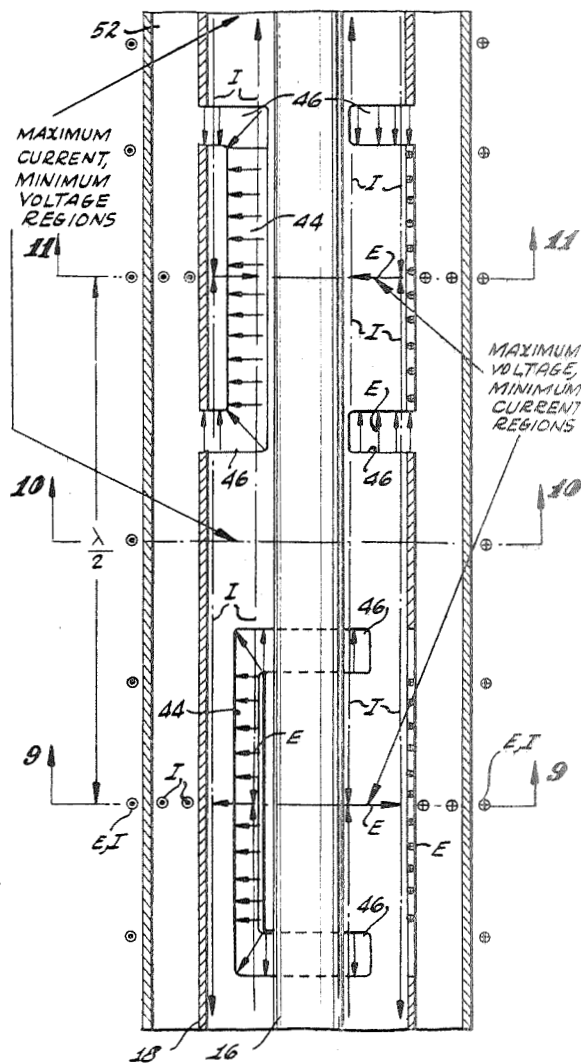


Fig. 8

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3,417,400

TRIAXIAL ANTENNA

Filed April 25, 1966

3 Sheets-Sheet 3

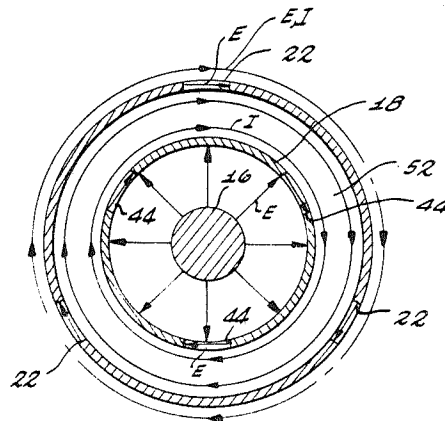


Fig. 9

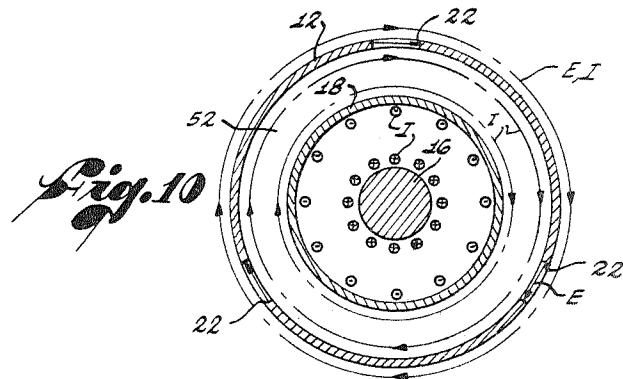


Fig. 10

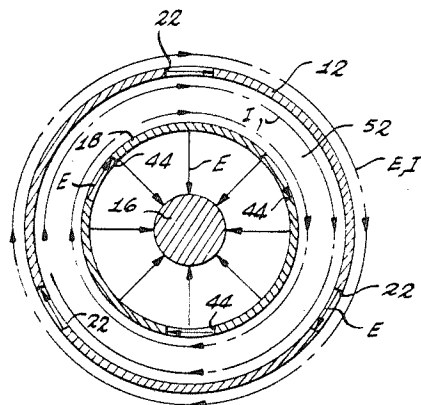


Fig. 11

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3,417,400

TRIAxIAL ANTENNA

Woodrow W. Black, Los Angeles, Calif., assignor, by
mesne assignments, to the United States of America
as represented by the Administrator of the National
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Filed Apr. 25, 1966, Ser. No. 544,895

9 Claims. (Cl. 343-771)

The present invention relates to improvements in anten-
nas, and more particularly to a novel, transversely
polarized triaxial antenna.

Prior art antennas are of a variety of configurations,
including coaxial antennas having post feed slots and the
clover leaf type of antennas. Although these antennas
have presented certain improvements in the art still
further improvements are needed.

In this respect the present invention is directed to a
horizontally polarized antenna arrangement of simplified
construction providing improvements in pattern and im-
pedance matching.

One object of this invention is to provide an improved
transversely or horizontally polarized antenna.

Another object of this invention is to provide an im-
proved antenna of the character referred to applicable
in the construction of a phased array transmitting antenna.

Another object of the present invention is to provide a
simple, compact, transversely polarized antenna of im-
proved construction which is inexpensive and relatively
easy to manufacture.

A further object of this invention is to provide an
improved antenna of the character referred to which is
capable of generating an omnidirectional radiation pat-
tern.

The foregoing and other objects and advantages of this
invention are achieved in a triaxial antenna construction
according to this invention comprising a shorted, coaxial,
TEM mode transmission line which includes an elongated
inner conductor, a tubular intermediate conductor dis-
posed about the inner conductor and provided with pre-
determined feed slot configurations. This transmission line
is disposed within an outer tubular conductor which is
provided with at least one elongated radiating slot which
substantially parallels the inner conductor. The antenna
is designed to provide a toroidal pattern with gain perpen-
dicular to the axis of the antenna. It is horizontally or
transversely polarized which minimizes reflections from
adjacent antenna elements. The pattern has low side lobes
and can be made to approach the maximum gain-band-
width configuration. The feed slots of the intermediate
tubular member of the antenna excite one or more long
radiating slots in the outer tubular member or conductor
of the antenna. The feed slots may be of various con-
figurations characterized by having a portion such as a
center section portion which is in line with or substan-
tially parallel to the axis of the antenna element. The slots
may be arranged to define a slot path around the inter-
mediate conductor or pluralities of the slots may be
arranged in axially spaced positions. The length of the
radiating slot or slots may be expressed as

$$\frac{M}{2} \lambda$$

where M is any whole number, for example, 1, 2, 3, etc.

The foregoing as well as other objects and advantages
of the present invention may be more clearly understood
by reference to the following detailed description when
considered with the drawings which, by way of example
only, illustrate different forms of antenna construction
embodying the advantages and features of the present
invention.

In the drawings:

FIGURE 1 is an elevational view, fragmentarily in
section, of one embodiment of the antenna of the present
invention showing a triaxial configuration comprising an
inner conductor, an intermediate tubular conductor and
an outer tubular conductor;

FIGURE 2 is a sectional view taken on the line 2—2
of FIGURE 1;

FIGURE 3 is an enlarged elevational view, fragmen-
tarily in section, of a portion of an intermediate tubular
conductor illustrating a feed slot configuration differing
from that of FIGURE 1;

FIGURE 4 is a sectional view taken along the line
4—4 of FIGURE 3;

FIGURE 5 is an elevational view drawn to the scale
of FIGURE 1 of a portion of an intermediate conductor
usable in the construction of FIGURE 1 and showing a
different configuration of feed slots;

FIGURE 6 is an enlarged sectional view taken along
the line 6—6 of FIGURE 5;

FIGURES 7 and 8 are enlarged longitudinal sectional
views, respectively, of selected portions of the antenna
construction illustrated in FIGURE 1 for the purpose of
demonstrating the theoretical concept explaining how
energy which is propagated axially of the inner and inter-
mediate conductors is transformed into energy radiating
transversely and circumferentially from the outer con-
ductor;

FIGURES 9, 10 and 11 are sectional views taken along
the respective sectional lines 9—9, 10—10 and 11—11
of FIGURE 8 illustrating the current and voltage con-
ditions within the antenna construction in planes placed
in quarter wavelength intervals from each other.

In the drawings, the triaxial antenna construction is
represented generally by the numeral 10 and comprises
a tubular, outer conductor 12 receiving one end of a
shorted, coaxial, TEM mode transmission line 14. The
transmission line 14 includes an elongated inner conduc-
tor 16 and a tubular intermediate conductor 18 having
a series of complex feed slots 20 formed therein. In the
operation of the antenna 10, the feed slots 20 excite
one or more axial, radiating slots 22 in the outer conduc-
tor 12 causing the outer conductor to circumferentially
radiate electromagnetic energy transverse to the axis of
the antenna 10, and preferably in an omnidirectional
radiation pattern in a plane perpendicular to the antenna
axis.

More specifically, in the form of the shorted coaxial
line 14 illustrated in FIGURE 1, the inner conductor 16
is an elongated cylindrical metal body, while the inter-
mediate conductor 18 is a hollow metal cylinder sur-
rounding the inner conductor and separated therefrom
by a plurality of insulating rings 24. An electrical short
26 is connected between the intermediate and inner con-
ductors 18 and 16 adjacent one end thereof and preferably
takes the form of a metal ring stationed around the inner
conductor with an outer edge bearing against the inner
wall of the intermediate conductor.

Ends of the inner and intermediate conductors 16 and
18 opposite the electrical short 26 are received by a con-
nector 28 for coupling energy to the antenna 10. The
connector 28 is of a conventional type and includes an
outer sleeve 30 having an internal collar 32 and an in-
ternally threaded end portion 34. The collar 32 supports
an annular insulating bead 36 for holding an end portion
38 of the inner conductor 16 within the connector 28,
and acts as an end stop for an enlarged end portion 40 of
the intermediate conductor 18, including an externally
threaded collar 42 mating with the internally threaded
portion 34 of the sleeve 30. Electrical energy applied to
the connector 28 causes the coaxial transmission line 14
to transmit TEM modes while the electrical short 26

establishes a standing wave pattern within the line including two separate series of one-half wavelength separated maximum current and voltage regions, the maximum current regions being spaced one-quarter wavelength from the maximum voltage regions and the electrical short 26 being located at a maximum current region.

It is well known that the TEM mode will not excite axial slots, such as the axial radiating slots 22 in the outer conductor 12. Therefore, to excite the radiating slots, the intermediate conductor 18 includes one or more series of complex feed slots 20. In the form of the antenna 10 illustrated in FIGURE 1, three series of feed slots are included and are equally spaced from each other around the intermediate conductor.

Generally speaking, the feed slots 20 are substantially one-half wavelength long and each includes an axial portion 44 substantially parallel to the inner conductor 16 and a transverse portion 46 extending from the associated axial portion and lying immediately adjacent a maximum current region. Also, the feed slots 20 are spaced substantially at multiples of one-half wavelength along the intermediate conductor 18 and transverse portions of even multiple feed slots are reversed in direction from transverse portions of odd and multiple feed slots (if any).

More particularly, in FIGURE 1, the feed slots 20 are generally U-shaped having relatively long axial portions 44 and relatively short transverse portions 46 at opposite ends of and substantially normal to the axial portions. Also, corresponding feed slots 20 in the three series of slots are aligned as groups with the transverse portions 46 of slots of each group extending in the same direction around the intermediate conductor 18.

As illustrated most clearly in FIGURES 7 through 11, the centers of the axial portions 44 are immediately adjacent maximum voltage regions while the maximum current regions lie between the transverse portions 46 of adjacent feed slots 20. Thus arranged, axial currents in the coaxial line 14 along the inner surface of the intermediate conductor 18 excite the transverse portions 46 of the feed slots 20 to induce voltage thereacross. Voltages induced across the transverse portions 46 are transposed 90° by the axial portions 44 of the feed slots to be of like instantaneous polarity in each axial portion and to induce circumferential currents of like direction around the outside of the intermediate conductor 18. The fields resulting from the circumferential currents, in turn, excite the axial radiating slots 22 in the outer conductor 12 to circumferentially radiate electromagnetic energy transverse to the axis of the antenna 10 and preferably in an omnidirectional radiation pattern as the antenna is rotated.

In this regard, the outer conductor 12 is a hollow metal cylinder and the axial slots 22 are each a multiple of one-half wavelength. Also, electrical shorts 48 and 50 are included adjacent opposite ends of the outer conductor 12 and between the outer and intermediate conductors and preferably comprise annular metal plugs seated around the intermediate conductor 18 at the ends of the outer conductor. The plugs and outer conductor define an annular chamber 52 around the intermediate conductor 18 which is substantially a multiple of one-half wavelength long with the electrical short 48 being substantially a multiple of one-half wavelengths beyond the middle of the endmost feed slot 20.

With the outer conductor 12 thus arranged, the circumferential currents between the intermediate and outer conductors excite the radiating slots 22 in the manner illustrated in FIGURES 7 through 11. In particular, a continuous sheet of current is induced along the outside of the outer conductor 12 which changes in direction at times corresponding to each half cycle, and electromagnetic energy radiates circumferentially from the outer conductor transverse to the axis of the antenna 10 and in an omnidirectional radiation pattern as the antenna is rotated around its longitudinal axis.

In the foregoing operation, the outer conductor 12 also acts as a polarizer for the antenna 10, blocking the

exit of any cross-polarized energy from the antenna, that is, energy other than that radiating circumferentially and substantially normal to the axis of the antenna.

From the foregoing, it is appreciated that the present invention provides a compact, transversely polarized, omnidirectional antenna design which is inexpensive and relatively easy to manufacture and assemble.

Within the basic framework of the triaxial antenna previously described, numerous changes and modifications may be made without departing from the spirit of the invention. For example, various numbers and combinations of feed and radiation slots may be employed. The length and angle of the slots may be altered relative to each other. Also, the design of the feed slots may be changed.

One such example of feed slot design change is illustrated in FIGURES 2 and 3 and another in FIGURES 4 and 5. In FIGURES 2 and 3, the feed slots 20' are generally Z-shaped having transverse portions 46' extending from opposite ends of and back along the axial portions 44'. The Z-shaped slots are substantially one-half wavelength long and are spaced at multiples of one-half wavelength with the transverse portions of even multiple feed slots being reversed in direction from the transverse portions of odd multiple feed slots.

As in the U-shaped slots, the transverse portions 46' are immediately adjacent maximum current regions. In fact, the maximum current regions are preferably located at the center of the axial portions 44'. This means that for the Z-shaped slot configuration, the electrical short 26' is spaced a multiple of one-half wavelength from the middle of the endmost Z-slot rather than an odd multiple of a quarter wavelength, as with the U-shaped feed slots.

With the Z-shaped slots and electrical short 26' thus spaced along the intermediate conductor 18', the mode of excitation of the feed slots and hence of the antenna 10 is very similar to that previously described. In particular, axial currents in the maximum current regions along the inner surface of the intermediate conductor 18 excite the transverse portions 46' to induce voltages thereacross. The voltages are transposed in direction normal to the antenna axis by the axial portions 44' and become of like instantaneous polarity in each axial portion. The voltages in axial portions, in turn, induce circumferential currents of like direction around the intermediate conductor which excite the radiating slots 22 of the associated outer conductor as described in connection with FIGURES 7-11.

In FIGURES 5 and 6, one or more axially extending zigzag slots 54 are spaced equally from each other around the intermediate conductor 18''. The slots 54 have portions conforming to half wavelength feed slots with axial portions 44'' and transverse end portions 46''. In fact, the slots 54 may be considered as being formed of a series of feed slots of the general design previously described joined end to end. That is, the feed slot portions are spaced one-half wavelength apart with the transverse portions 46'' of even multiple feed slot portions reversed in direction from the transverse portions of odd multiple feed slot portions. Also, the transverse portions are immediately adjacent maximum current regions in the conductor 18'' and the mode of exciting the slots to excite the radiating slots is as previously described for the U-shaped feed slots.

In view of the foregoing as well as other changes and modifications which may be made in the illustrated forms within the spirit of the present invention, it is intended that the invention be limited in scope only by the terms of the following claims.

I claim:

1. A transversely polarized triaxial antenna, comprising:

a shorted coaxial TEM mode transmission line including an inner elongated conductor, a tubular intermediate conductor substantially coaxial with and receiving said inner conductor, and first short means adjacent a first end of said intermediate conductor

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- and between said intermediate and inner conductors responsive to electrical energy applied to a second end of said line for setting up a standing wave pattern in said line including separate series of one-half wavelength spaced maximum current and voltage regions; 5
said intermediate conductor including a series of complex feed slots in its outer wall, each being substantially one-half wavelength long and each having an axial portion substantially parallel to said inner conductor and a transverse portion connected to said axial portion and lying immediately adjacent a maximum current region, said feed slots being located at multiples of one-half wavelength along said intermediate conductor with the transverse portions of even multiple feed slots being reversed in direction from the transverse portions of odd multiple feed slots; 10
a tubular outer conductor substantially coaxial with and receiving said intermediate conductor and having an axial radiating slot substantially parallel to said inner conductor, said radiating slot being substantially a multiple of one-half wavelength long; 15
and second and third short means adjacent first and second ends of said outer conductor and between said outer and intermediate conductors to define a chamber around said intermediate conductor, said chamber being substantially a multiple of one-half wavelength long and said second short means being substantially a multiple of one-half wavelength beyond the center of the endmost feed slot in said intermediate conductor. 20
2. The triaxial antenna of claim 1, wherein said feed slots are generally U-shaped with the center of the axial portions being immediately adjacent maximum voltage regions in said coaxial line, maximum current regions being spaced at one-quarter wavelength intervals from said maximum voltage regions. 25
3. The triaxial antenna of claim 1, wherein said feed slots are generally Z-shaped. 30
4. The triaxial antenna of claim 3, wherein the center of the axial portions of said feed slots lie immediately adjacent maximum current regions in said coaxial transmission line and wherein said transverse portions of said feed slots extend from ends of said axial portions back along said axial portions toward said maximum current regions. 35
5. The triaxial antenna of claim 1, wherein said series of feed slots define a single, elongated slot comprising a plurality of substantially half wavelength feed slots joined end to end. 40 45 50

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6. The triaxial antenna of claim 5, wherein said transverse portions extend axially from the opposite ends of said axial portions.
7. The triaxial antenna of claim 1, including a plurality of series of feed slots spaced equally from each other around said intermediate conductor.
8. The triaxial antenna of claim 7, wherein said feed slots are generally U-shaped with centers of said axial portions immediately adjacent maximum voltage regions in said coaxial line.
9. A transversely polarized triaxial antenna, comprising:
a shorted coaxial TEM mode transmission line including an inner elongated conductor, a tubular intermediate conductor substantially coaxial with and receiving said inner conductor, and first electrical short means adjacent a first end of said intermediate conductor and between said intermediate and inner conductors responsive to electrical energy applied to a second end of said line for setting up a standing wave pattern in said coaxial line including separate series of half wavelength spaced maximum current and voltage regions;
said intermediate conductor including a complex feed slot substantially one-half wavelength long and having an axial portion substantially parallel to said inner conductor and a transverse portion connecting to said axial portion and lying immediately adjacent a maximum current region;
a tubular outer conductor substantially coaxial with and receiving said intermediate conductor and having an axial radiating slot substantially parallel to said inner conductor, said radiating slot being substantially a multiple of one-half wavelength long;
and second and third short means adjacent first and second ends of said outer conductor and between said outer and intermediate conductors to define a chamber around said intermediate conductor, said chamber being substantially a multiple of one-half wavelength long and said second short means being substantially a multiple of one-half wavelength beyond the center of said feed slot.

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